19-5307; Rev 0; 6/10

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

General Description

The MAX19993 dual-channel downconverter is designed to provide 6.4dB of conversion gain, +27dBm input IP3, 15.4dBm 1dB input compression point, and a noise figure of 9.8dB for 1200MHz to 1700MHz diversity receiver applications. With an optimized LO frequency range of 1000MHz to 1560MHz, this mixer is ideal for low-side LO injection architectures. High-side LO injection is supported by the MAX19993A, which is pin-pin and functionally compatible with the MAX19993.

In addition to offering excellent linearity and noise performance, the MAX19993 also yields a high level of component integration. This device includes two double-balanced passive mixer cores, two LO buffers, a dual-input LO selectable switch, and a pair of differential IF output amplifiers. Integrated on-chip baluns allow for single-ended RF and LO inputs. The device requires a nominal LO drive of 0dBm and a typical supply current of 337mA at V_{CC} = +5.0V or 275mA at V_{CC} = +3.3V.

The MAX19993 is pin compatible with the MAX9985/MAX19985A/MAX9995/MAX19993A/MAX19994/MAX19994A/MAX19995/MAX19995A series of 700MHz to 2200MHz mixers and pin similar to the MAX19997A/MAX19999 series of 1850MHz to 4000MHz mixers, making this entire family of downconverters ideal for applications where a common PCB layout is used across multiple frequency bands.

The device is available in a 6mm x 6mm, 36-pin TQFN package with an exposed pad. Electrical performance is guaranteed over the extended temperature range, from T_C = -40°C to +85°C.

Applications

WCDMA/LTE Base Stations

Wireless Local Loop

Fixed Broadband Wireless Access

Private Mobile Radios

Military Systems

Features

- **1200MHz to 1700MHz RF Frequency Range**
- **1000MHz to 1560MHz LO Frequency Range**
- **50MHz to 500MHz IF Frequency Range**
- **6.4dB Typical Conversion Gain**
- **9.8dB Typical Noise Figure**
- **+27dBm Typical Input IP3**
- **15.4dBm Typical Input 1dB Compression Point**
- **72dBc Typical 2RF - 2LO Spurious Rejection at P_{RF} = -10dBm**
- **Dual Channels Ideal for Diversity Receiver Applications**
- **47dB Typical Channel-to-Channel Isolation**
- **Low -6dBm to +3dBm LO Drive**
- **Integrated LO Buffer**
- **Internal RF and LO Baluns for Single-Ended Inputs**
- **Built-In SPDT LO Switch with 57dB LO-to-LO Isolation and 50ns Switching Time**
- **Pin Compatible with the MAX9985/MAX19985A/MAX9995/MAX19993A/MAX19994/MAX19994A/MAX19995/MAX19995A Series of 700MHz to 2200MHz Mixers**
- **Pin Similar to the MAX19997A/MAX19999 Series of 1850MHz to 4000MHz Mixers**
- **Single +5V or +3.3V Supply**
- **External Current-Setting Resistors Provide Option for Operating Device in Reduced-Power/Reduced-Performance Mode**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX19993ETX+	-40°C to +85°C	36 TQFN-EP*
MAX19993ETX+T	-40°C to +85°C	36 TQFN-EP*

+Denotes a lead(Pb)-free/RoHS-compliant package.
**EP = Exposed pad.*
T = Tape and reel.

ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND...-0.3V to +5.5V
LO1, LO2 to GND... ±0.3V
LOSEL to GND .... -0.3V to (V_{CC} + 0.3V)
RFMAIN, RFDIV, and LO_ Input Power .... +15dBm
RFMAIN, RFDIV Current (RF is DC shorted to GND through a balun)..50mA
TAPMAIN, TAPDIV to GND ....-0.3V to +2V
Any Other Pins to GND .... -0.3V to (V_{CC} + 0.3V)
Continuous Power Dissipation (Note 1) 8.7W
θ_{JA} (Notes 2, 3) .... +38°C/W
θ_{JC} (Notes 1, 3) ....7.4°C/W
Operating Temperature Range (Note 4)... T_C = -40°C to +85°C
Junction Temperature ....+150°C
Storage Temperature Range........................... -65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°C
Soldering Temperature (reflow) ....+260°C

Note 1: Based on junction temperature $T_J = T_C + (\theta_{JC} \times V_{CC} \times I_{CC})$. This formula can be used when the temperature of the exposed pad is known while the device is soldered down to a PCB. See the *Applications Information* section for details. The junction temperature must not exceed +150°C.
Note 2: Junction temperature $T_J = T_A + (\theta_{JA} \times V_{CC} \times I_{CC})$. This formula can be used when the ambient temperature of the PCB is known. The junction temperature must not exceed +150°C.
Note 3: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maxim-ic.com/thermal-tutorial**.
Note 4: T_C is the temperature on the exposed pad of the package. T_A is the ambient temperature of the device and PCB.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

5.0V SUPPLY DC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit*, V_{CC} = 4.75V to 5.25V, no input AC signals. T_C = -40°C to +85°C, R1 = R4 = 681Ω, R2 = R5 = 1.82kΩ. Typical values are at V_{CC} = 5.0V, T_C = +25°C, unless otherwise noted. All parameters are production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		4.75	5	5.25	V
Supply Current	I_{CC}	Total supply current		337	400	mA
LOSEL Input High Voltage	V_{IH}		2			V
LOSEL Input Low Voltage	V_{IL}				0.8	V
LOSEL Input Current	I_{IH} and I_{IL}		-10		+10	µA

3.3V SUPPLY DC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit*, V_{CC} = 3.0V to 3.6V, no input AC signals. T_C = -40°C to +85°C, R1 = R4 = 681Ω, R2 = R5 = 1.43kΩ. Typical values are at V_{CC} = 3.3V, T_C = +25°C, unless otherwise noted. Parameters are guaranteed by design and not production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		3.0	3.3	3.6	V
Supply Current	I_{CC}	Total supply current (Note 5)		275		mA
LOSEL Input High Voltage	V_{IH}			2		V
LOSEL Input Low Voltage	V_{IL}			0.8		V

RECOMMENDED AC OPERATING CONDITIONS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
RF Frequency	f_{RF}	(Note 6)	1200		1700	MHz
LO Frequency	f_{LO}	(Note 6)	1000		1560	MHz
IF Frequency	f_{IF}	Using Mini-Circuits TC4-1W-17 4:1 transformer as defined in the *Typical Application Circuit*, IF matching components affect the IF frequency range (Note 6)	100		500	MHz
		Using Mini-Circuits TC4-1W-7A 4:1 transformer as defined in the *Typical Application Circuit*, IF matching components affect the IF frequency range (Note 6)	50		250	
LO Drive Level	P_{LO}	(Note 6)	-6		+3	dBm

5.0V SUPPLY, LOW-SIDE INJECTION AC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit* (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.82kΩ, V_{CC} = 4.75V to 5.25V, RF and LO ports are driven from 50Ω sources, P_{LO} = -6dBm to +3dBm, P_{RF} = -5dBm, f_{RF} = 1200MHz to 1700MHz, f_{LO} = 1060MHz to 1560MHz, f_{IF} = 140MHz, $f_{RF} > f_{LO}$, T_C = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, P_{RF} = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C. All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Conversion Gain (Note 5)	G_C		4.5	6.4	7.4	dB
		T_C = +25°C	5.1	6.4	7.0	
		T_C = +25°C, f_{RF} = 1427MHz to 1463MHz	5.2	6.4	6.9	
Conversion Gain Flatness	ΔG_C	f_{RF} = 1427MHz to 1463MHz		±0.03		dB
Gain Variation Over Temperature	TC_{CG}	T_C = -40°C to +85°C		-0.009		dB/°C
Input Compression Point	IP_{1dB}	f_{RF} = 1450MHz (Notes 5, 8)	12.9	15.4		dBm
Input Third-Order Intercept Point	IIP3	f_{RF1} - f_{RF2} = 1MHz, P_{RF} = -5dBm per tone	24.0	27.0		dBm
		f_{RF1} - f_{RF2} = 1MHz, P_{RF} = -5dBm per tone, f_{RF} = 1427MHz to 1463MHz, T_C = +25°C (Note 5)	24.8	27.0		
		f_{RF1} - f_{RF2} = 1MHz, P_{RF} = -5dBm per tone, f_{RF} = 1427MHz to 1463MHz (Note 5)	24.4	27.0		
Input Third-Order Intercept Point Variation Over Temperature	TC_{IIP3}	f_{RF1} - f_{RF2} = 1MHz, P_{RF} = -5dBm per tone, T_C = -40°C to +85°C		±0.5		dBm
Noise Figure (Note 9)	NF_{SSB}	Single sideband, no blockers present		9.8	12.7	dB
		f_{RF} = 1427MHz to 1463MHz, T_C = +25°C, P_{LO} = 0dBm, single sideband, no blockers present		9.8	11.0	
		f_{RF} = 1427MHz to 1463MHz, P_{LO} = 0dBm, single sideband, no blockers present		9.8	12.0	

5.0V SUPPLY, LOW-SIDE INJECTION AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Application Circuit* (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.82kΩ, V_{CC} = 4.75V to 5.25V, RF and LO ports are driven from 50Ω sources, P_{LO} = -6dBm to +3dBm, P_{RF} = -5dBm, f_{RF} = 1200MHz to 1700MHz, f_{LO} = 1060MHz to 1560MHz, f_{IF} = 140MHz, $f_{RF} > f_{LO}$, T_C = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, P_{RF} = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C. All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Noise Figure Temperature Coefficient	TC_{NF}	Single sideband, no blockers present, T_C = -40°C to +85°C			0.016		dB/°C
Noise Figure with Blocker	NF_B	$P_{BLOCKER}$ = +8dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, $f_{BLOCKER}$ = 1550MHz, P_{LO} = 0dBm, V_{CC} = 5.0V, T_C = +25°C (Notes 9, 10)			21.0	22.8	dB
2RF - 2LO Spur Rejection (Note 9)	2x2	f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{SPUR} = 1380MHz	P_{RF} = -10dBm	58	72		dBc
			P_{RF} = -5dBm	53	67		
		f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{SPUR} = 1380MHz, P_{LO} = 0dBm, V_{CC} = 5.0V, T_C = +25°C	P_{RF} = -10dBm	61	72		dBc
			P_{RF} = -5dBm	56	67		
3RF - 3LO Spur Rejection (Note 9)	3x3	f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{SPUR} = 1356.67MHz	P_{RF} = -10dBm	77	93		dBc
			P_{RF} = -5dBm	67	83		
		f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{SPUR} = 1356.67MHz, P_{LO} = 0dBm, V_{CC} = 5.0V, T_C = +25°C	P_{RF} = -10dBm	82	93		dBc
			P_{RF} = -5dBm	72	83		
RF Input Return Loss		LO and IF terminated into matched impedance, LO on			21		dB
LO Input Return Loss		LO port selected, RF and IF terminated into matched impedance			24		dB
		LO port unselected, RF and IF terminated into matched impedance			27		
IF Output Impedance	Z_{IF}	Nominal differential impedance of the IF outputs			200		Ω
IF Output Return Loss		RF terminated into 50Ω, LO driven by 50Ω source, IF transformed to 50Ω using external components shown in the *Typical Application Circuit*			15		dB
RF-to-IF Isolation		(Note 5)			33		dB
LO Leakage at RF Port					-38		dBm
2LO Leakage at RF Port					-27		dBm

5.0V SUPPLY, LOW-SIDE INJECTION AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Application Circuit* (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.82kΩ, V_{CC} = 4.75V to 5.25V, RF and LO ports are driven from 50Ω sources, P_{LO} = -6dBm to +3dBm, P_{RF} = -5dBm, f_{RF} = 1200MHz to 1700MHz, f_{LO} = 1060MHz to 1560MHz, f_{IF} = 140MHz, $f_{RF} > f_{LO}$, T_C = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, P_{RF} = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C. All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LO Leakage at IF Port		(Note 5)		-18		dBm
Channel Isolation (Note 5)		RFMAIN converted power measured at IFDIV relative to IFMAIN, all unused ports terminated to 50Ω	43	47		dB
		RFDIV converted power measured at IFMAIN relative to IFDIV, all unused ports terminated to 50Ω	43	47		
LO-to-LO Isolation		P_{LO1} = +3dBm, P_{LO2} = +3dBm, f_{LO1} = 1310MHz, f_{LO2} = 1311MHz (Note 5)	47	57		dB
LO Switching Time		50% of LOSEL to IF settled within 2 degrees		50		ns

3.3V SUPPLY, LOW SIDE INJECTION AC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit* (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.43kΩ. Typical values are at V_{CC} = 3.3V, P_{RF} = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C, unless otherwise noted.) (Note 7)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Conversion Gain	G_C	(Note 5)		6.2		dB
Conversion Gain Flatness	ΔG_C	f_{RF} = 1427MHz to 1463MHz		±0.05		dB
Gain Variation Over Temperature	TC_{CG}	T_C = -40°C to +85°C		-0.009		dB/°C
Input Compression Point	IP_{1dB}	(Note 8)		12.8		dBm
Input Third-Order Intercept Point	IIP3	f_{RF1} - f_{RF2} = 1MHz		24.4		dBm
Input Third-Order Intercept Point Variation Over Temperature	TC_{IIP3}	f_{RF1} - f_{RF2} = 1MHz, P_{RF} = -5dBm per tone, T_C = -40°C to +85°C		±0.8		dBm
Noise Figure	NF_{SSB}	Single sideband, no blockers present		9.8		dB
Noise Figure Temperature Coefficient	TC_{NF}	Single sideband, no blockers present, T_C = -40°C to +85°C		0.016		dB/°C
2RF - 2LO Spur Rejection	2 x 2	P_{RF} = -10dBm		73		dBc
		P_{RF} = -5dBm		68		
3RF - 3LO Spur Rejection	3 x 3	P_{RF} = -10dBm		80		dBc
		P_{RF} = -5dBm		70		
RF Input Return Loss		LO and IF terminated into matched impedance, LO on		21		dB
LO Input Return Loss		LO port selected, RF and IF terminated into matched impedance		24		dB
		LO port unselected, RF and IF terminated into matched impedance		27		

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

3.3V SUPPLY, LOW SIDE INJECTION AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Application Circuit* (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.43kΩ. Typical values are at V_{CC} = 3.3V, P_{RF} = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C, unless otherwise noted.) (Note 7)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
IF Output Return Loss		RF terminated into 50Ω, LO driven by 50Ω source, IF transformed to 50Ω using external components shown in the *Typical Application Circuit*		15		dB
RF-to-IF Isolation				33		dB
LO Leakage at RF Port				-45		dBm
2LO Leakage at RF Port				-27		dBm
LO Leakage at IF Port				-22		dBm
Channel Isolation		RFMAIN converted power measured at IFDIV relative to IFMAIN, all unused ports terminated to 50Ω		47		dB
		RFDIV converted power measured at IFMAIN relative to IFDIV, all unused ports terminated to 50Ω		47		
LO-to-LO Isolation		P_{LO1} = +3dBm, P_{LO2} = +3dBm, f_{LO1} = 1310MHz, f_{LO2} = 1311MHz		57		dB
LO Switching Time		50% of LOSEL to IF settled within 2 degrees		50		ns

Note 5: 100% production tested for functionality.

Note 6: Not production tested. Operation outside this range is possible, but with degraded performance of some parameters. See the *Typical Operating Characteristics* section.

Note 7: All limits reflect losses of external components, including a 0.5dB loss at f_{IF} = 140MHz due to the 4:1 transformer. Output measurements were taken at IF outputs of the *Typical Application Circuit*.

Note 8: Maximum reliable continuous input power applied to the RF or IF port of this device is +12dBm from a 50Ω source.

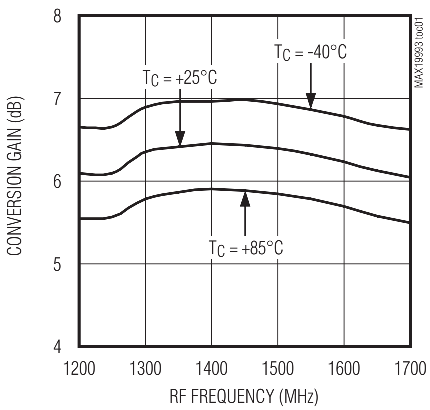
Note 9: Not production tested.

Note 10: Measured with external LO source noise filtered so the noise floor is -174dBm/Hz. This specification reflects the effects of all SNR degradations in the mixer, including the LO noise as defined in Application Note 2021: *Specifications and Measurement of Local Oscillator Noise in Integrated Circuit Base Station Mixers*.

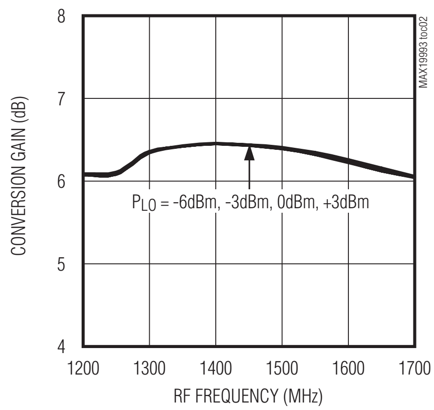
Typical Operating Characteristics

(*Typical Application Circuit* (see Table 1). **V_{CC} = 5.0V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C = +25°C, unless otherwise noted.)

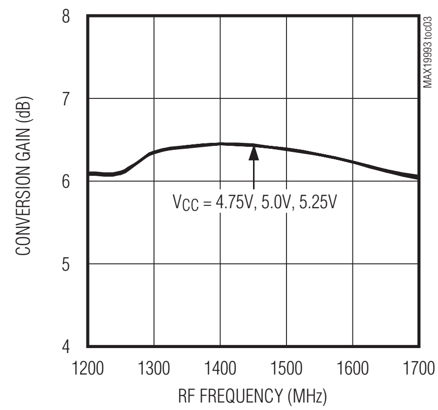
CONVERSION GAIN vs. RF FREQUENCY



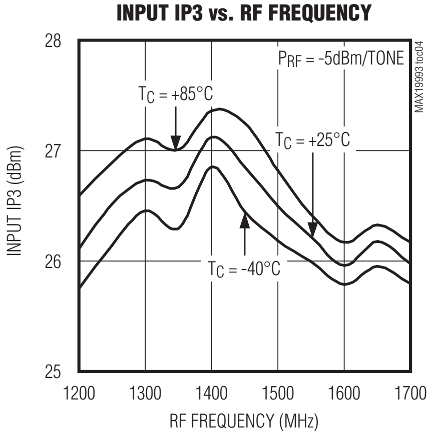
CONVERSION GAIN vs. RF FREQUENCY



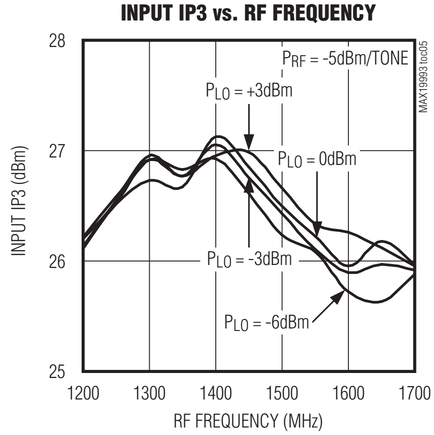
CONVERSION GAIN vs. RF FREQUENCY



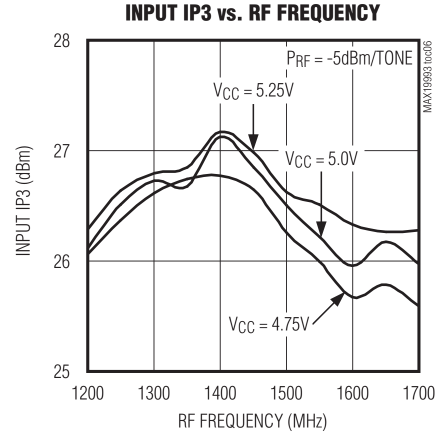
INPUT IP3 vs. RF FREQUENCY



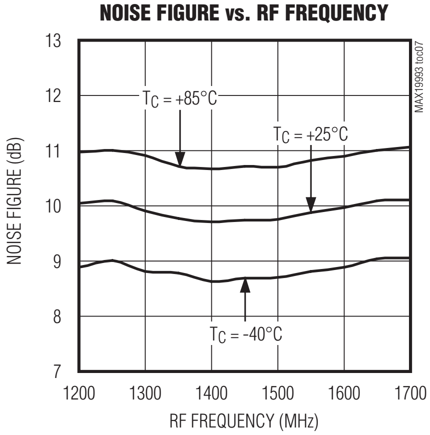
INPUT IP3 vs. RF FREQUENCY



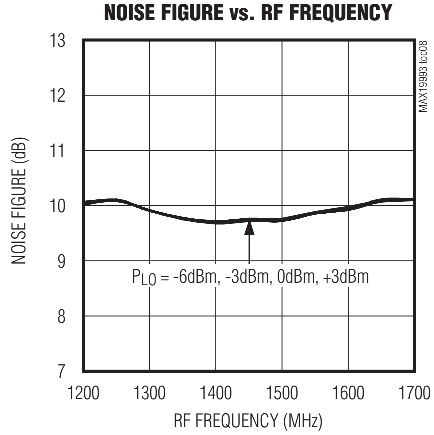
INPUT IP3 vs. RF FREQUENCY



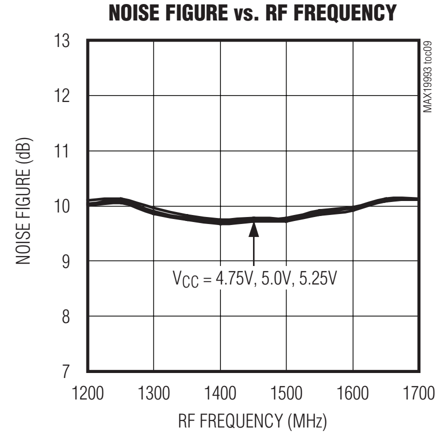
NOISE FIGURE vs. RF FREQUENCY



NOISE FIGURE vs. RF FREQUENCY



NOISE FIGURE vs. RF FREQUENCY

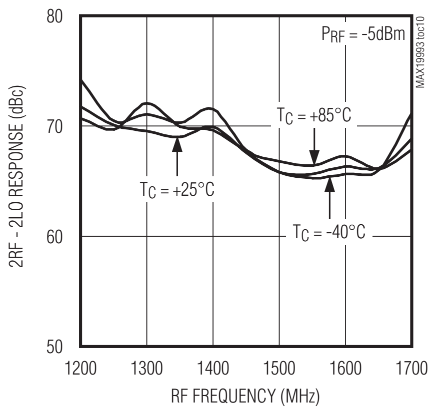


Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

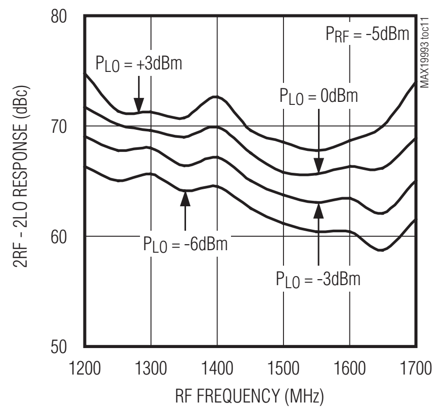
Typical Operating Characteristics (continued)

(*Typical Application Circuit* (see Table 1). **V_{CC} = 5.0V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C = +25°C, unless otherwise noted.)

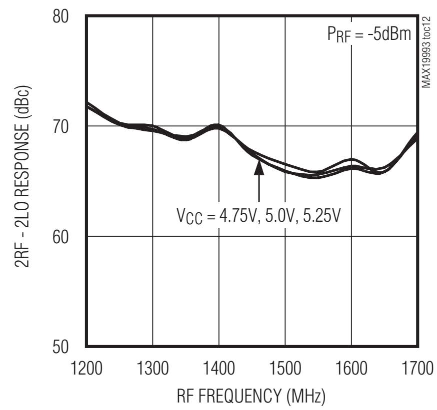
2RF - 2LO RESPONSE vs. RF FREQUENCY



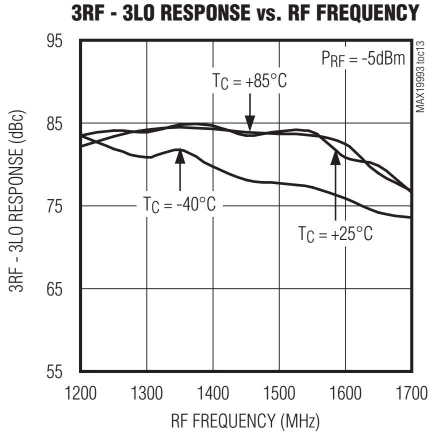
2RF - 2LO RESPONSE vs. RF FREQUENCY



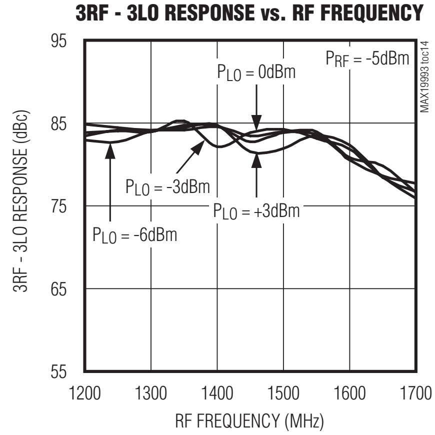
2RF - 2LO RESPONSE vs. RF FREQUENCY



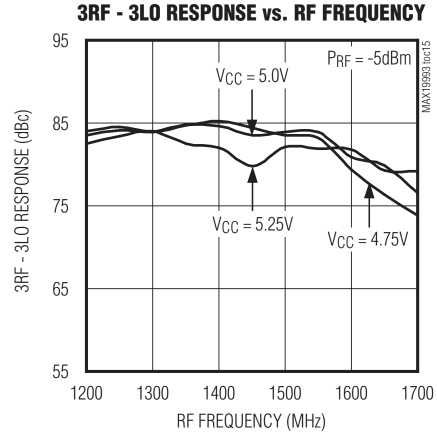
3RF - 3LO RESPONSE vs. RF FREQUENCY



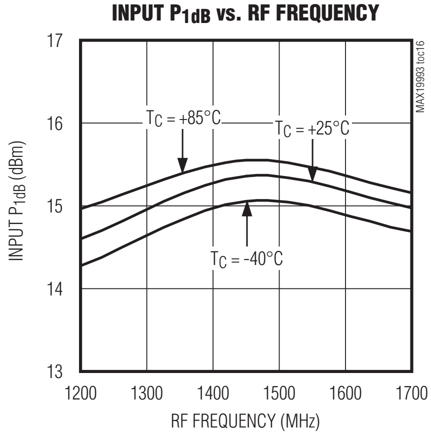
3RF - 3LO RESPONSE vs. RF FREQUENCY



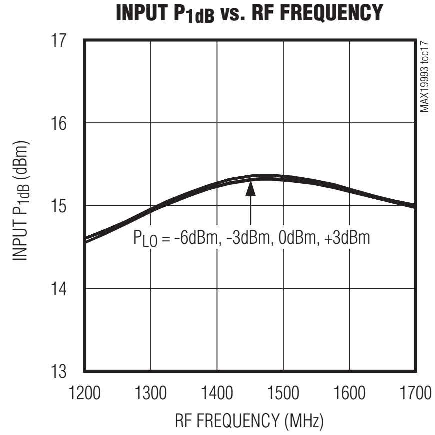
3RF - 3LO RESPONSE vs. RF FREQUENCY



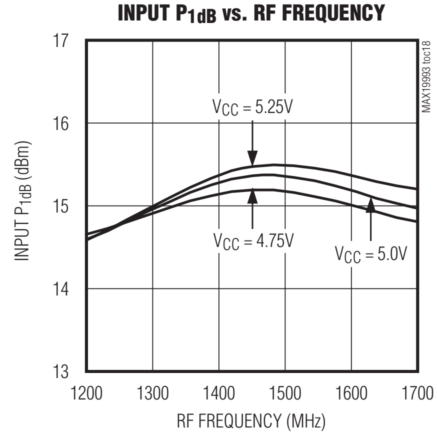
INPUT P_{1dB} vs. RF FREQUENCY



INPUT P_{1dB} vs. RF FREQUENCY



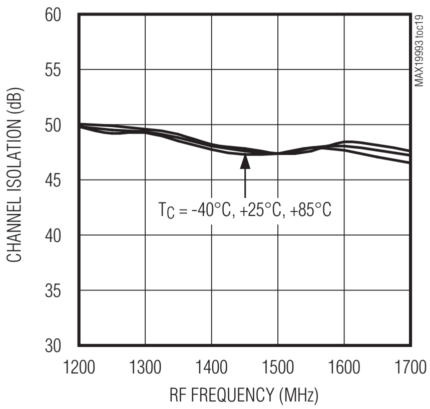
INPUT P_{1dB} vs. RF FREQUENCY



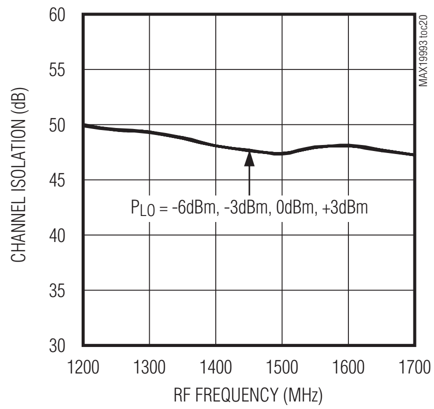
Typical Operating Characteristics (continued)

(*Typical Application Circuit* (see Table 1). **V_{CC} = 5.0V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C = +25°C, unless otherwise noted.)

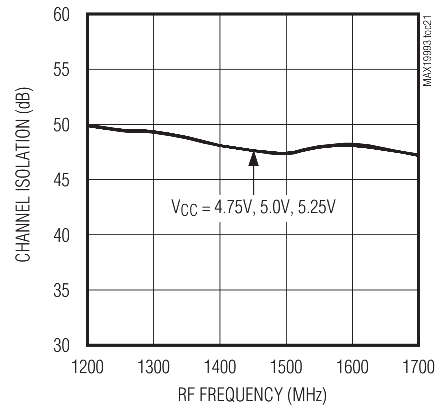
CHANNEL ISOLATION vs. RF FREQUENCY



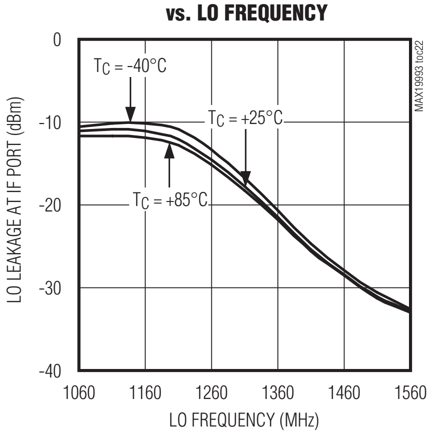
CHANNEL ISOLATION vs. RF FREQUENCY



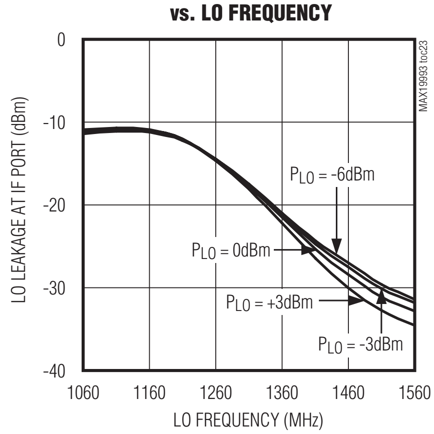
CHANNEL ISOLATION vs. RF FREQUENCY



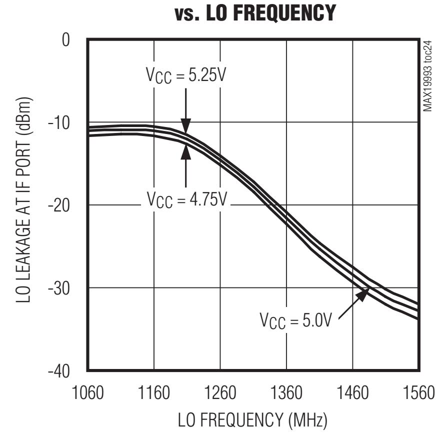
LO LEAKAGE AT IF PORT vs. LO FREQUENCY



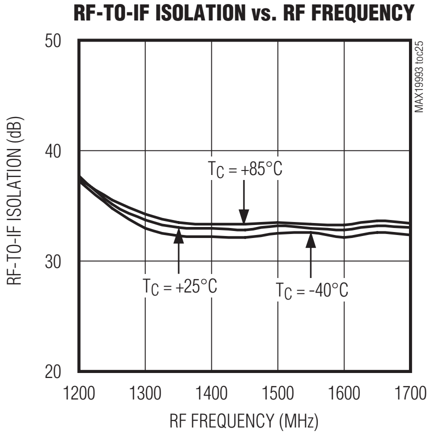
LO LEAKAGE AT IF PORT vs. LO FREQUENCY



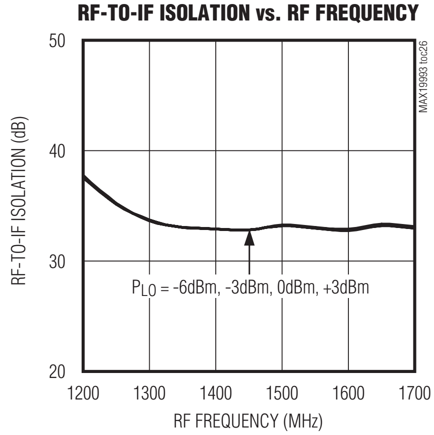
LO LEAKAGE AT IF PORT vs. LO FREQUENCY



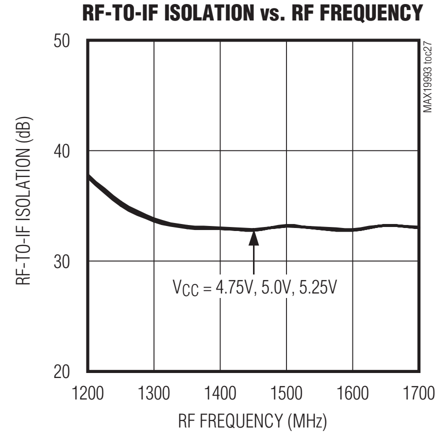
RF-TO-IF ISOLATION vs. RF FREQUENCY



RF-TO-IF ISOLATION vs. RF FREQUENCY



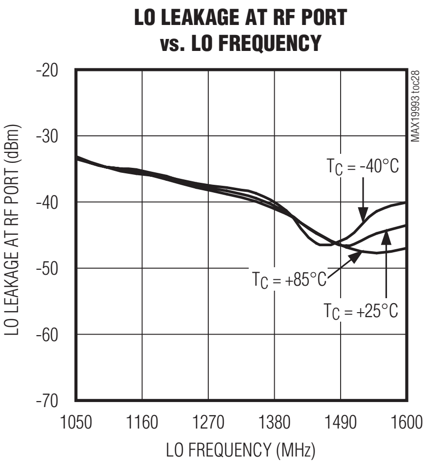
RF-TO-IF ISOLATION vs. RF FREQUENCY

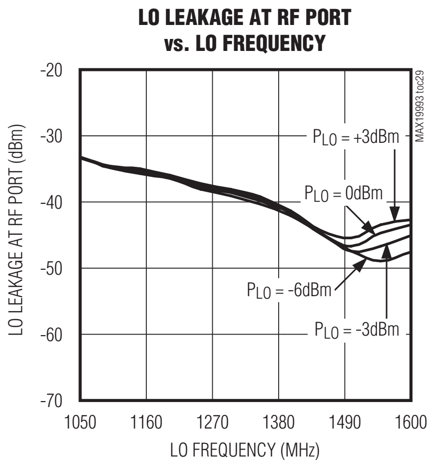


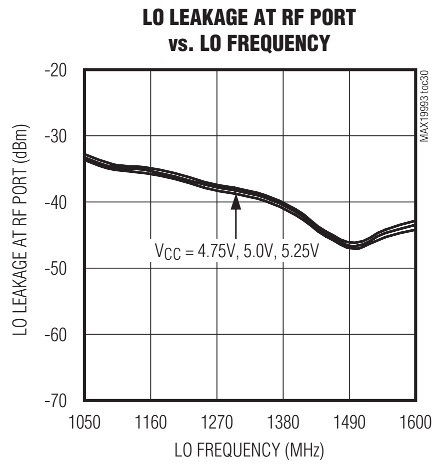
Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

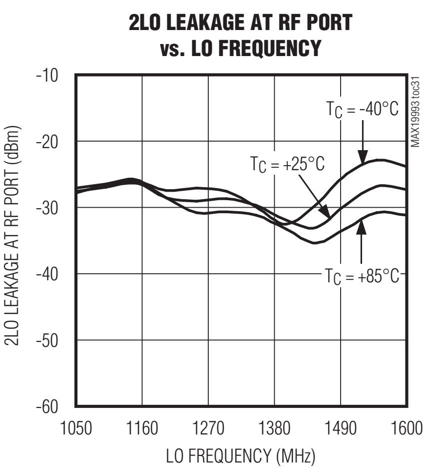
Typical Operating Characteristics (continued)

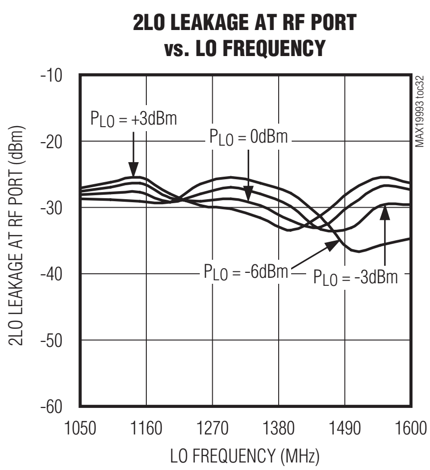
(*Typical Application Circuit* (see Table 1). **V_{CC} = 5.0V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C = +25°C, unless otherwise noted.)

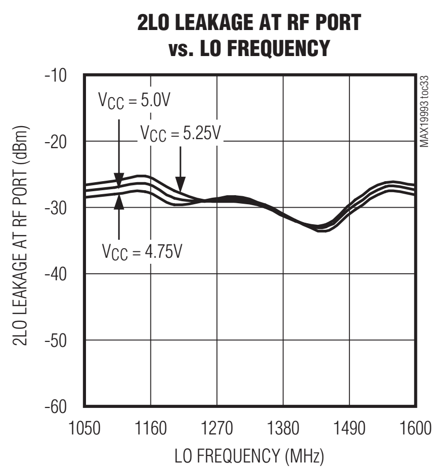


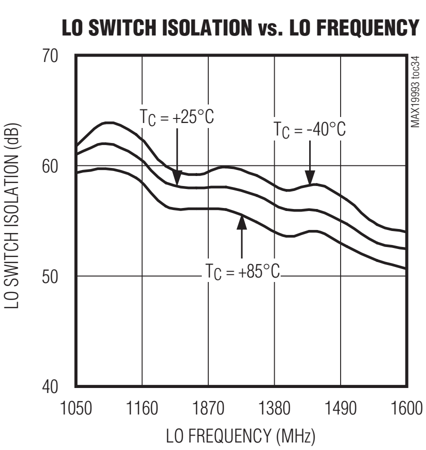


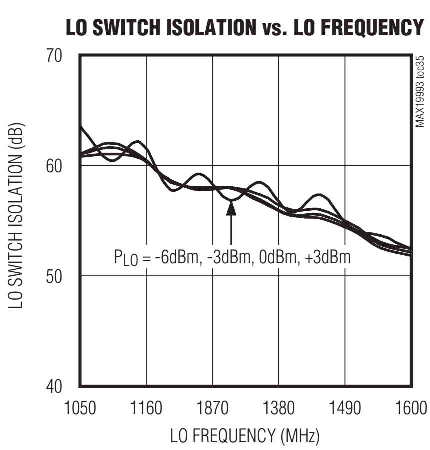


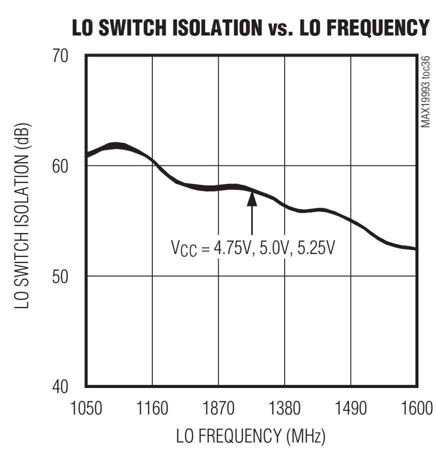








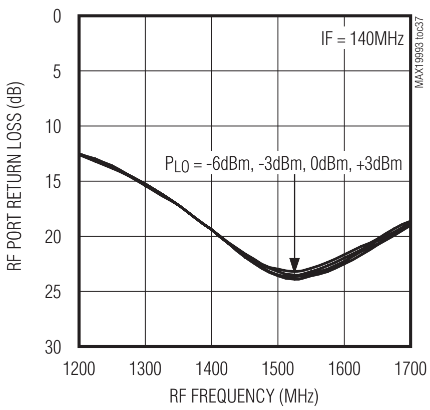




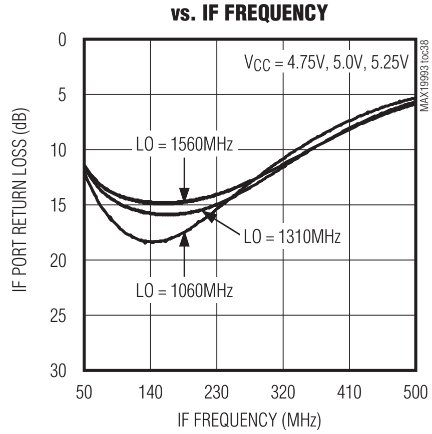
Typical Operating Characteristics (continued)

(*Typical Application Circuit* (see Table 1). **V_{CC} = 5.0V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C = +25°C, unless otherwise noted.)

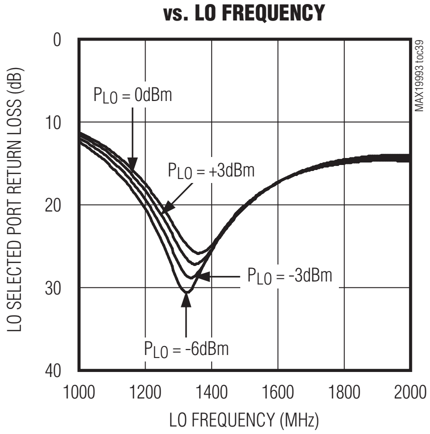
RF PORT RETURN LOSS vs. RF FREQUENCY



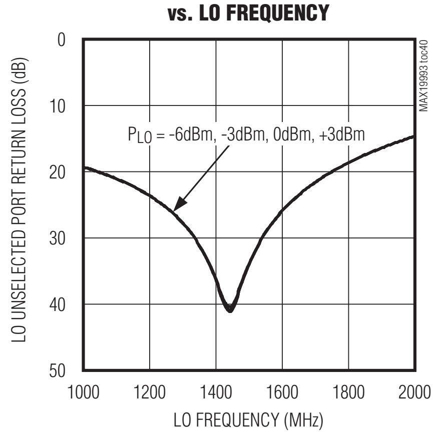
IF PORT RETURN LOSS vs. IF FREQUENCY



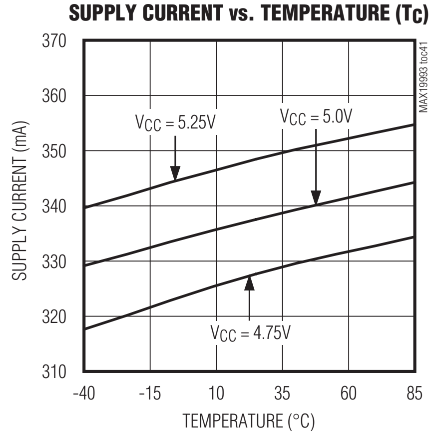
LO SELECTED PORT RETURN LOSS vs. LO FREQUENCY



LO UNSELECTED PORT RETURN LOSS vs. LO FREQUENCY



SUPPLY CURRENT vs. TEMPERATURE (T_C)

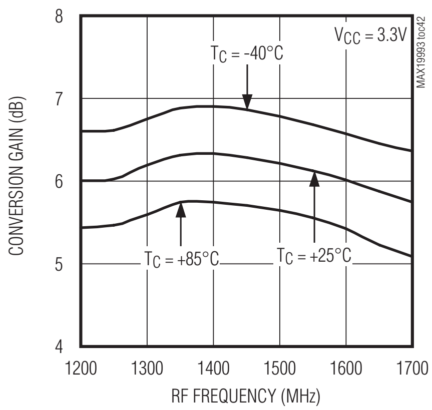


Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

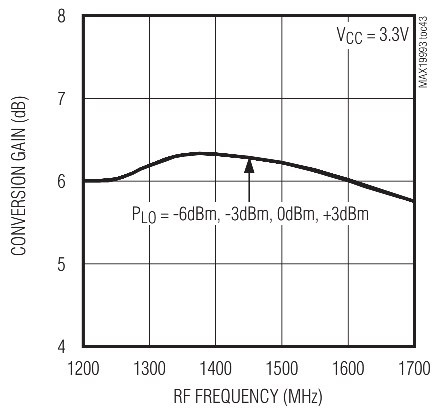
Typical Operating Characteristics (continued)

(*Typical Application Circuit* (see Table 1). **V_{CC} = 3.3V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C = +25°C, unless otherwise noted.)

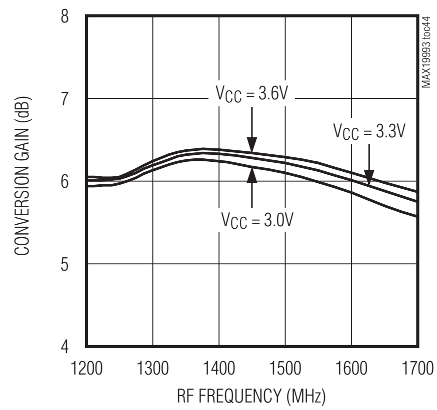
CONVERSION GAIN vs. RF FREQUENCY



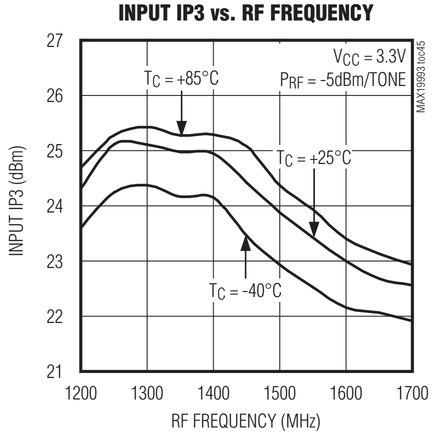
CONVERSION GAIN vs. RF FREQUENCY



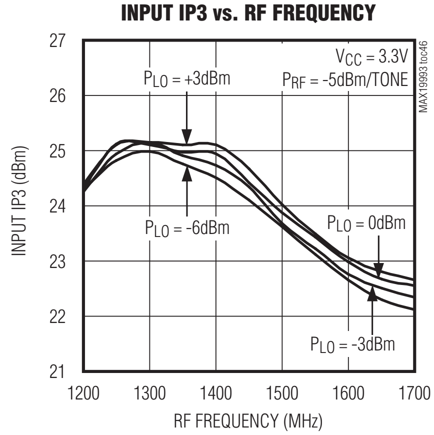
CONVERSION GAIN vs. RF FREQUENCY



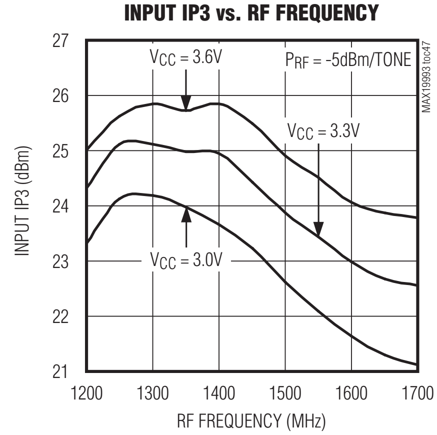
INPUT IP3 vs. RF FREQUENCY



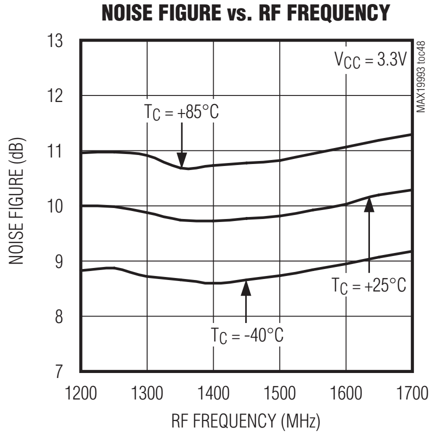
INPUT IP3 vs. RF FREQUENCY



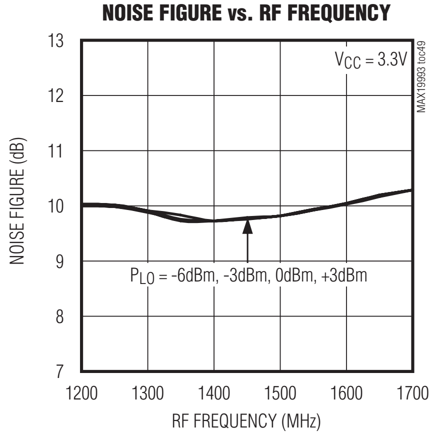
INPUT IP3 vs. RF FREQUENCY



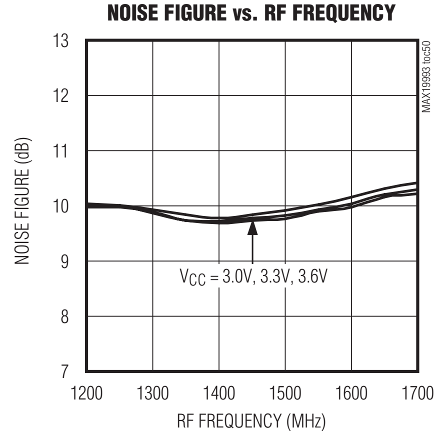
NOISE FIGURE vs. RF FREQUENCY



NOISE FIGURE vs. RF FREQUENCY

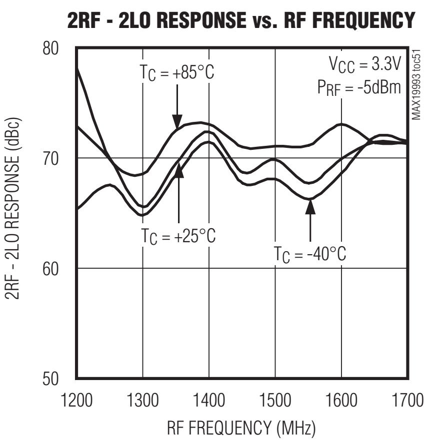


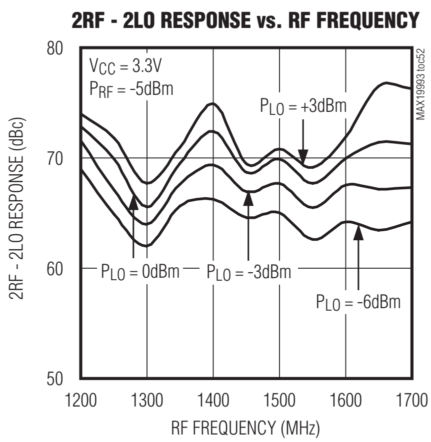
NOISE FIGURE vs. RF FREQUENCY

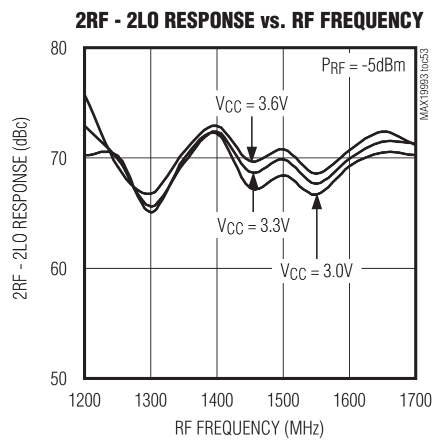


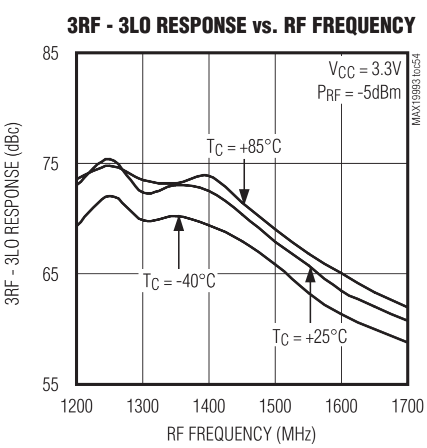
Typical Operating Characteristics (continued)

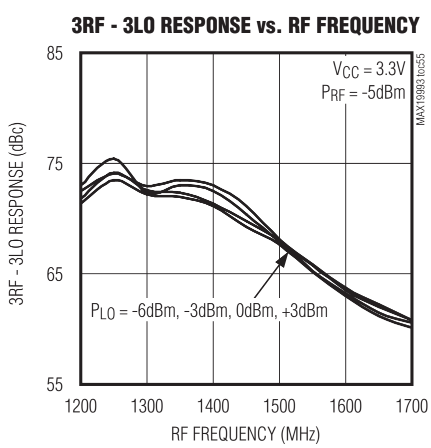
(*Typical Application Circuit* (see Table 1). **V_{CC} = 3.3V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C +25°C, unless otherwise noted.)

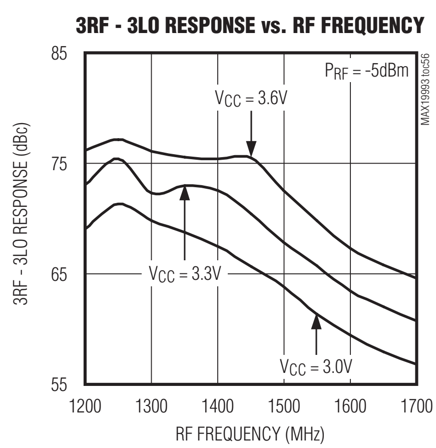


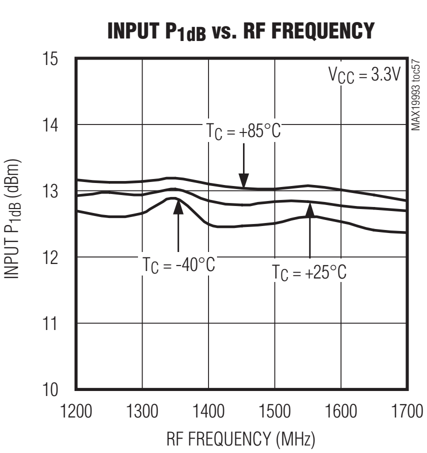


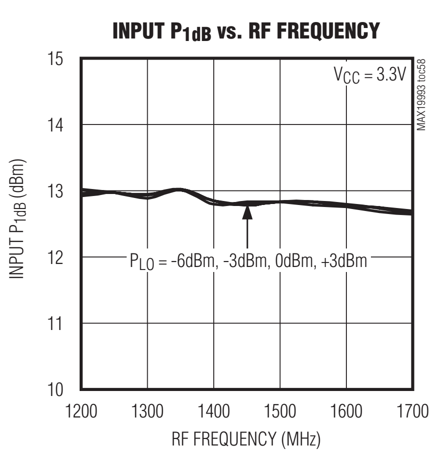


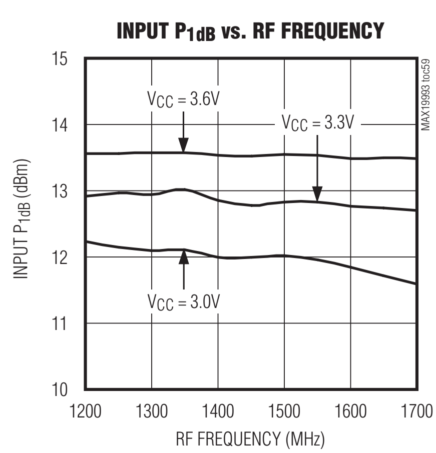










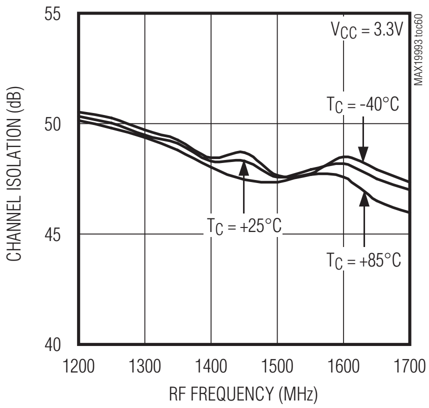


Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

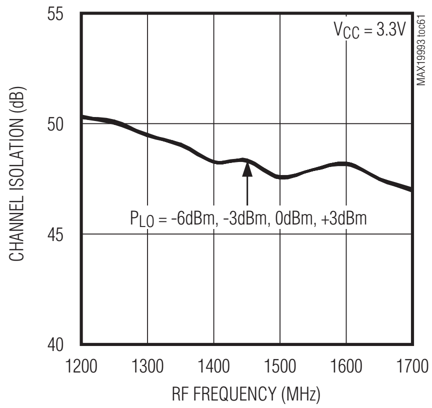
Typical Operating Characteristics (continued)

(*Typical Application Circuit* (see Table 1). **V_{CC} = 3.3V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C +25°C, unless otherwise noted.)

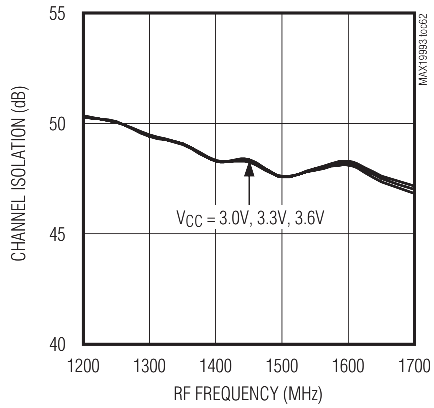
CHANNEL ISOLATION vs. RF FREQUENCY



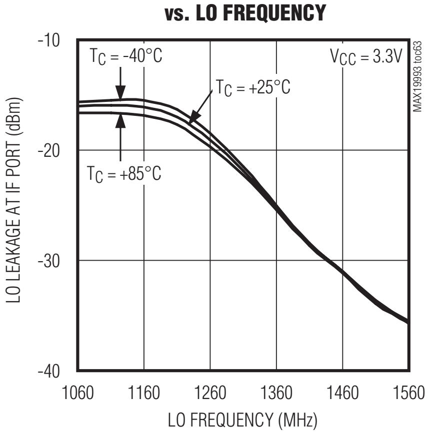
CHANNEL ISOLATION vs. RF FREQUENCY



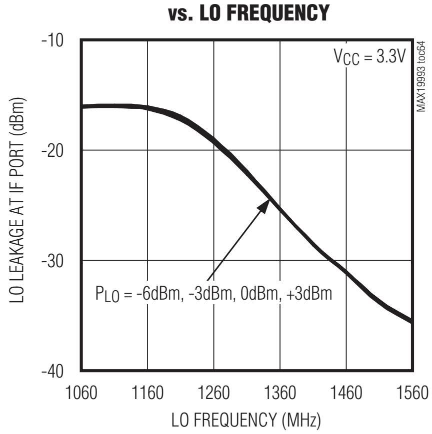
CHANNEL ISOLATION vs. RF FREQUENCY



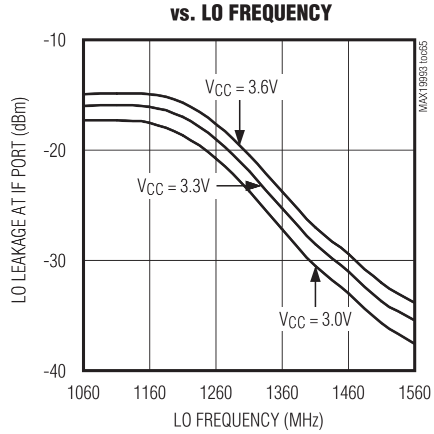
LO LEAKAGE AT IF PORT vs. LO FREQUENCY



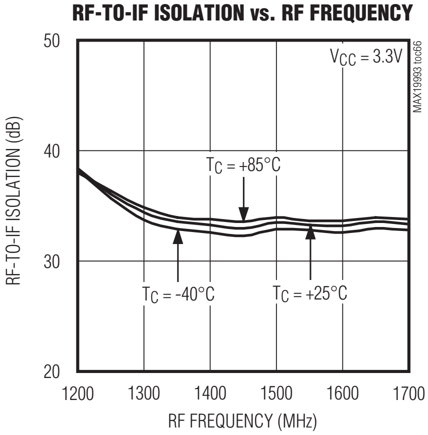
LO LEAKAGE AT IF PORT vs. LO FREQUENCY



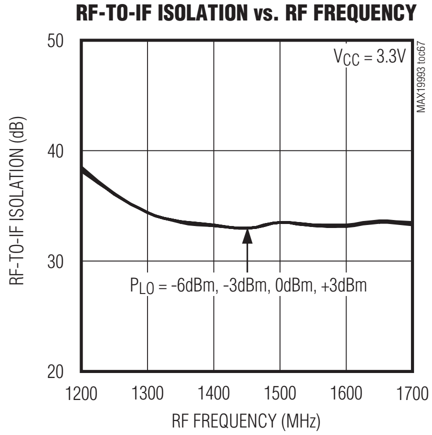
LO LEAKAGE AT IF PORT vs. LO FREQUENCY



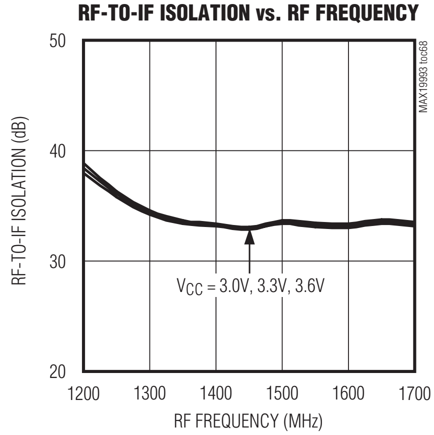
RF-TO-IF ISOLATION vs. RF FREQUENCY



RF-TO-IF ISOLATION vs. RF FREQUENCY



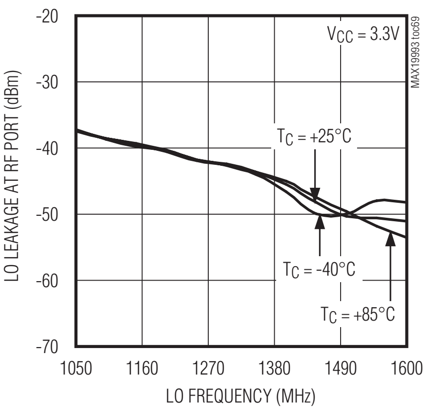
RF-TO-IF ISOLATION vs. RF FREQUENCY



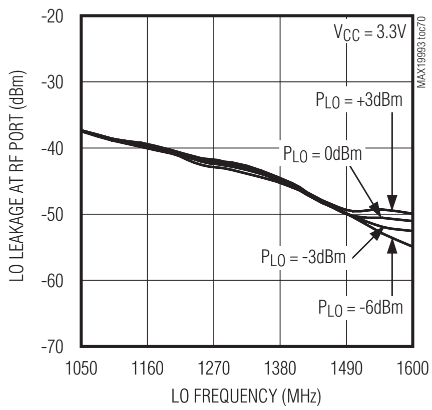
Typical Operating Characteristics (continued)

(*Typical Application Circuit* (see Table 1). **V_{CC} = 3.3V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C +25°C, unless otherwise noted.)

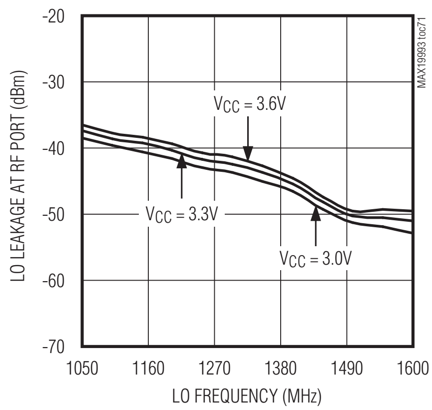
LO LEAKAGE AT RF PORT vs. LO FREQUENCY



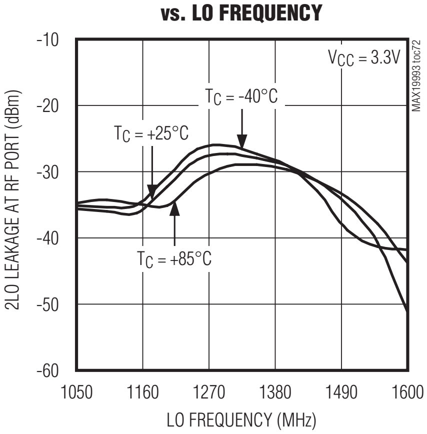
LO LEAKAGE AT RF PORT vs. LO FREQUENCY



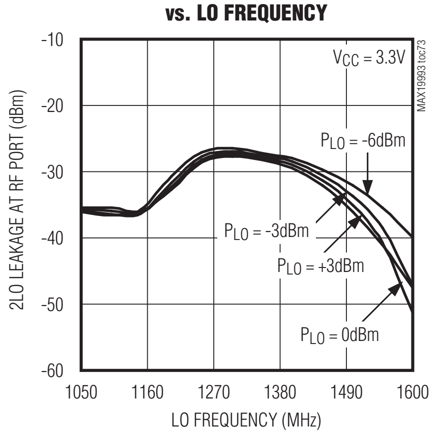
LO LEAKAGE AT RF PORT vs. LO FREQUENCY



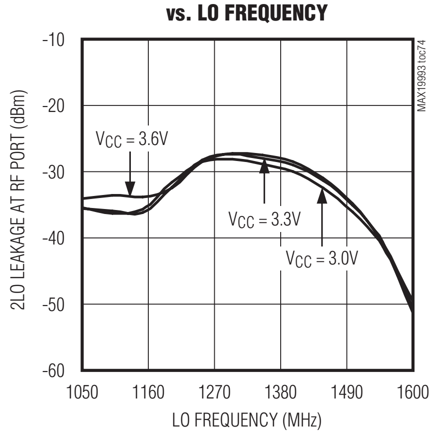
2LO LEAKAGE AT RF PORT vs. LO FREQUENCY



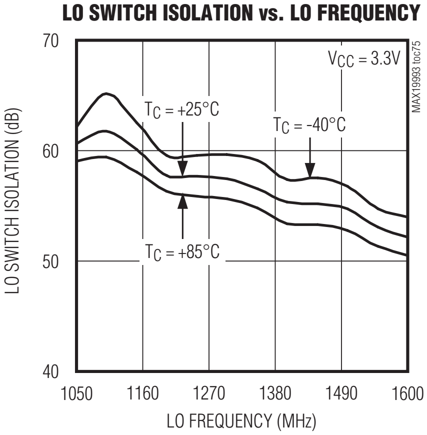
2LO LEAKAGE AT RF PORT vs. LO FREQUENCY



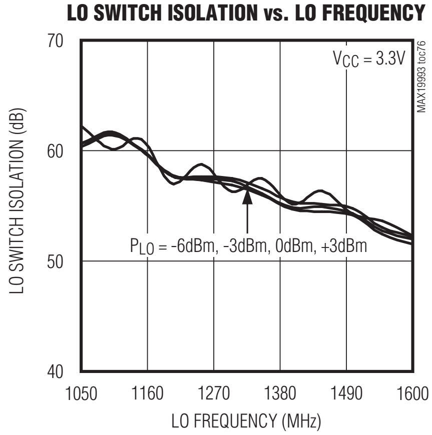
2LO LEAKAGE AT RF PORT vs. LO FREQUENCY



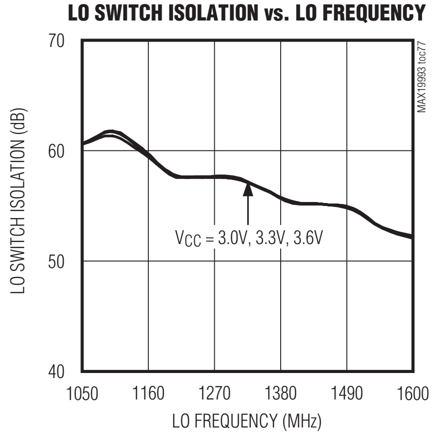
LO SWITCH ISOLATION vs. LO FREQUENCY



LO SWITCH ISOLATION vs. LO FREQUENCY



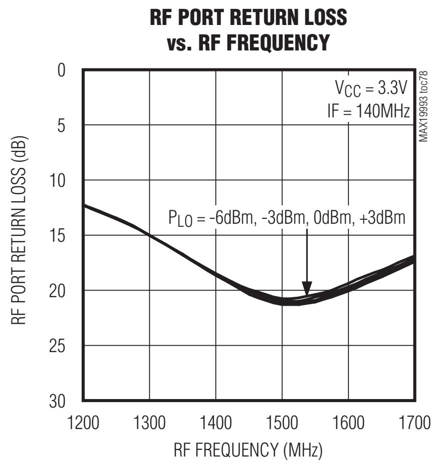
LO SWITCH ISOLATION vs. LO FREQUENCY

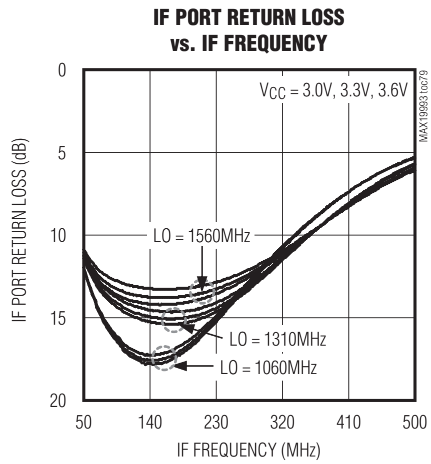


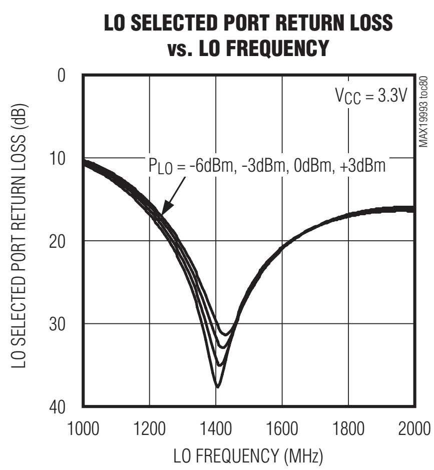
Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

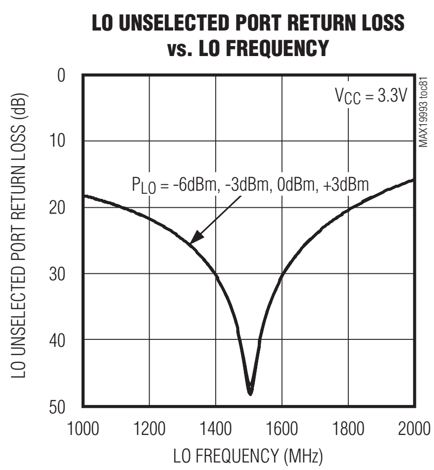
Typical Operating Characteristics (continued)

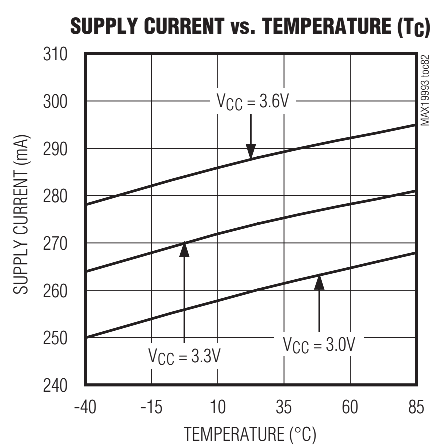
(*Typical Application Circuit* (see Table 1). **V_{CC} = 3.3V**, $f_{RF} > f_{LO}$ for a 140MHz IF, P_{RF} = -5dBm, P_{LO} = 0dBm, T_C +25°C, unless otherwise noted.)



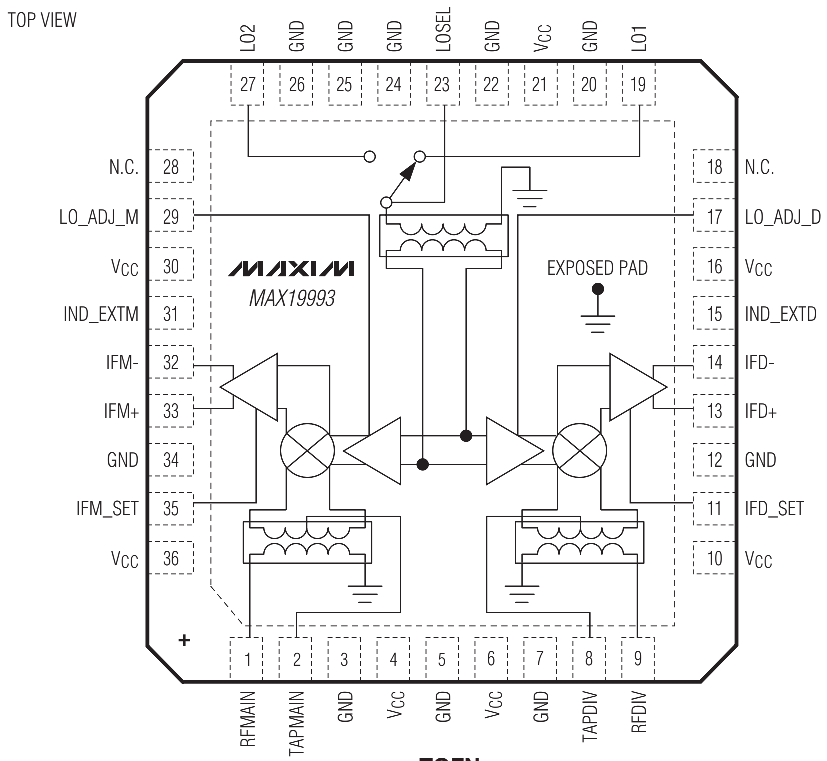








Pin Configuration



TQFN
(6mm × 6mm)

EXPOSED PAD ON THE BOTTOM OF THE PACKAGE

Pin Description

PIN	NAME	FUNCTION
1	RFMAIN	Main Channel RF Input. Internally matched to 50Ω. Requires an input DC-blocking capacitor.
2	TAPMAIN	Main Channel Balun Center Tap. Bypass to GND with 39pF and 0.033µF capacitors as close as possible to the pin with the smaller value capacitor closer to the part.
3, 5, 7, 12, 20, 22, 24, 25, 26, 34	GND	Ground
4, 6, 10, 16, 21, 30, 36	V_{CC}	Power Supply. Bypass to GND with capacitors as close as possible to the pin, as shown in the *Typical Application Circuit*.
8	TAPDIV	Diversity Channel Balun Center Tap. Bypass to GND with 39pF and 0.033µF capacitors as close as possible to the pin with the smaller value capacitor closer to the part.
9	RFDIV	Diversity Channel RF Input. Internally matched to 50Ω. Requires an input DC-blocking capacitor.
11	IFD_SET	IF Diversity Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the diversity IF amplifier. See the *Typical Application Circuit*.
13, 14	IFD+, IFD-	Diversity Mixer Differential IF Output +/-. Connect pullup inductors from each of these pins to V_{CC}. See the *Typical Application Circuit*.
15	IND_EXTD	Diversity External Inductor Connection. Connect to ground through a 0Ω resistor (0603) as close as possible to the pin. For improved RF-to-IF and LO-to-IF isolation, contact the factory for details.
17	LO_ADJ_D	LO Diversity Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the diversity LO amplifier. See the *Typical Application Circuit*.
18, 28	N.C.	No Connection. Not internally connected.
19	LO1	Local Oscillator 1 Input. This input is internally matched to 50Ω. Requires an input DC-blocking capacitor.
23	LOSEL	Local Oscillator Select. Set this pin to high to select LO1. Set to low to select LO2.
27	LO2	Local Oscillator 2 Input. This input is internally matched to 50Ω. Requires an input DC-blocking capacitor.
29	LO_ADJ_M	LO Main Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the main LO amplifier. See the *Typical Application Circuit*.
31	IND_EXTM	Main External Inductor Connection. Connect to ground through a 0Ω resistor (0603) as close as possible to the pin. For improved RF-to-IF and LO-to-IF isolation, contact the factory for details.
32, 33	IFM-, IFM+	Main Mixer Differential IF Output -/+. Connect pullup inductors from each of these pins to V_{CC}. See the *Typical Application Circuit*.
35	IFM_SET	IF Main Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the main IF amplifier. See the *Typical Application Circuit*.
—	EP	Exposed Pad. Internally connected to GND. Solder this exposed pad to a PCB pad that uses multiple ground vias to provide heat transfer out of the device into the PCB ground planes. These multiple ground vias are also required to achieve the noted RF performance.

Detailed Description

The MAX19993 is a dual-channel downconverter designed to provide up to 6.4dB of conversion gain, +27dBm input IP3, 15.4dBm 1dB input compression point, and a noise figure of 9.8dB.

In addition to its high-linearity performance, the device achieves a high level of component integration. It integrates two double-balanced mixers for two-channel downconversion. Both the main and diversity channels include a balun and matching circuitry to allow 50Ω single-ended interfaces to the RF ports and the two LO ports. An integrated single-pole/double-throw (SPDT) switch provides 50ns switching time between the two LO inputs with 57dB of LO-to-LO isolation and -38dBm of LO leakage at the RF port. Furthermore, the integrated LO buffers provide a high drive level to each mixer core, reducing the LO drive required at the device's inputs to a range of -6dBm to +3dBm. The IF ports for both channels incorporate differential outputs for downconversion, which is ideal for providing enhanced 2RF - 2LO performance.

The device is specified to operate over an RF input range of 1200MHz to 1700MHz, an LO range of 1000MHz to 1560MHz, and an IF range of 50MHz to 500MHz. The external IF components set the lower frequency range. See the *Typical Operating Characteristics* section for details. Operation beyond these ranges is possible; see the *Typical Operating Characteristics* section for additional information. Although this device is optimized for low-side LO injection applications, it can operate in high-side LO injection modes as well. However, performance degrades as f_{LO} continues to increase. Contact the factory for a variant with increased high-side LO performance.

RF Port and Balun

The RF input ports of both the main and diversity channels are internally matched to 50Ω, requiring no external matching components. A DC-blocking capacitor is required as the input is internally DC shorted to ground through the on-chip balun. The RF port input return loss is typically better than 19dB over the 1400MHz to 1700MHz RF frequency range.

LO Inputs, Buffer, and Balun

The device is optimized for a 1000MHz to 1560MHz LO frequency range. As an added feature, the device includes an internal LO SPDT switch for use in frequency-hopping applications. The switch selects one of the two single-ended LO ports, allowing the external oscillator to settle on a particular frequency before it is switched in. LO switching time is typically 50ns, which is more than adequate for typical GSM applications. If frequency hopping is not employed, simply set the switch to either of the LO inputs. The switch is controlled by a digital input (LOSEL), where logic-high selects LO1 and logic-low selects LO2. LO1 and LO2 inputs are internally matched to 50Ω, requiring only 39pF DC-blocking capacitors.

If LOSEL is connected directly to a logic source, then voltage **MUST** be applied to V_{CC} before digital logic is applied to LOSEL to avoid damaging the part. Alternatively, a 1kΩ resistor can be placed in series at the LOSEL to limit the input current in applications where LOSEL is applied before V_{CC}.

The main and diversity channels incorporate a two-stage LO buffer that allows for a wide-input power range for the LO drive. The on-chip low-loss baluns, along with LO buffers, drive the double-balanced mixers. All interfacing and matching components from the LO inputs to the IF outputs are integrated on-chip.

High-Linearity Mixer

The core of the device's dual-channel downconverter consists of two double-balanced, high-performance passive mixers. Exceptional linearity is provided by the large LO swing from the on-chip LO buffers. When combined with the integrated IF amplifiers, the cascaded IIP3, 2RF - 2LO rejection, and noise-figure performance are typically +27dBm, 72dBc, and 9.8dB, respectively.

Differential IF

The device has a 50MHz to 500MHz IF frequency range, where the low-end frequency depends on the frequency response of the external IF components. Note that these differential ports are ideal for providing enhanced IIP2 performance. Single-ended IF applications require a 4:1 (impedance ratio) balun to transform the 200Ω differential IF impedance to a 50Ω single-ended system. After the balun, the return loss is typically 15dB. The user can use a differential IF amplifier on the mixer IF ports, but a DC block is required on both IFD+/IFD- and IFM+/IFM- ports to keep external DC from entering the IF ports of the mixer.

Applications Information

Input and Output Matching

The RF and LO inputs are internally matched to 50Ω. No matching components are required. The RF port input return loss is typically better than 19dB over the 1400MHz to 1700MHz RF frequency range and return loss at the LO ports are typically better than 15dB over the entire LO range. RF and LO inputs require only DC-blocking capacitors for interfacing.

The IF output impedance is 200Ω (differential). For evaluation, an external low-loss 4:1 (impedance ratio) balun transforms this impedance to a 50Ω single-ended output. See the *Typical Application Circuit*.

Reduced-Power Mode

Each channel of the device has two pins (LO_ADJ_D/LO_ADJ_M, IFD_SET/IFM_SET) that allow external resistors to set the internal bias currents. Nominal values for these resistors are given in Table 1. Larger value resistors can be used to reduce power dissipation at the expense of some performance loss. If ±1% resistors are not readily available, substitute with ±5% resistors.

Significant reductions in power consumption can also be realized by operating the mixer with an optional 3.3V supply voltage. Doing so reduces the overall power consumption by approximately 46%. See the *3.3V Supply DC Electrical Characteristics* table and the relevant 3.3V curves in the *Typical Operating Characteristics* section.

IND_EXT_ Inductors

The default application circuit calls for connecting IND_EXT_ (pins 15 and 31) to ground through a 0Ω resistor (0603) as close as possible to the pin. For improved RF-to-IF and LO-to-IF isolation, contact the factory for details.

Layout Considerations

A properly designed PCB is an essential part of any RF/microwave circuit. Keep RF signal lines as short as possible to reduce losses, radiation, and inductance. The load impedance presented to the mixer must be such that any capacitance from both IF- and IF+ to ground does not exceed several picofarads. For the best performance, route the ground pin traces directly to the exposed pad under the package. The PCB exposed pad **MUST** be connected to the ground plane of the PCB. It is suggested that multiple vias be used to connect this pad to the lower-level ground planes. This method provides a good RF/thermal-conduction path for the device. Solder the exposed pad on the bottom of the device package to the PCB. The MAX19993 evaluation kit can be used as a reference for board layout. Gerber files are available upon request at **www.maxim-ic.com**.

Power-Supply Bypassing

Proper voltage-supply bypassing is essential for high-frequency circuit stability. Bypass each V_{CC} pin and TAPMAIN/TAPDIV with the capacitors shown in the *Typical Application Circuit*. See Table 1 for component values. Place the TAPMAIN/TAPDIV bypass capacitors to ground within 100 mils of the pin.

Exposed Pad RF/Thermal Considerations

The exposed pad (EP) of the MAX19993's 36-pin TQFN-EP package provides a low thermal-resistance path to the die. It is important that the PCB on which the device is mounted be designed to conduct heat from the EP. In addition, provide the EP with a low-inductance path to electrical ground. The EP **MUST** be soldered to a ground plane on the PCB, either directly or through an array of plated via holes.

Typical Application Circuit

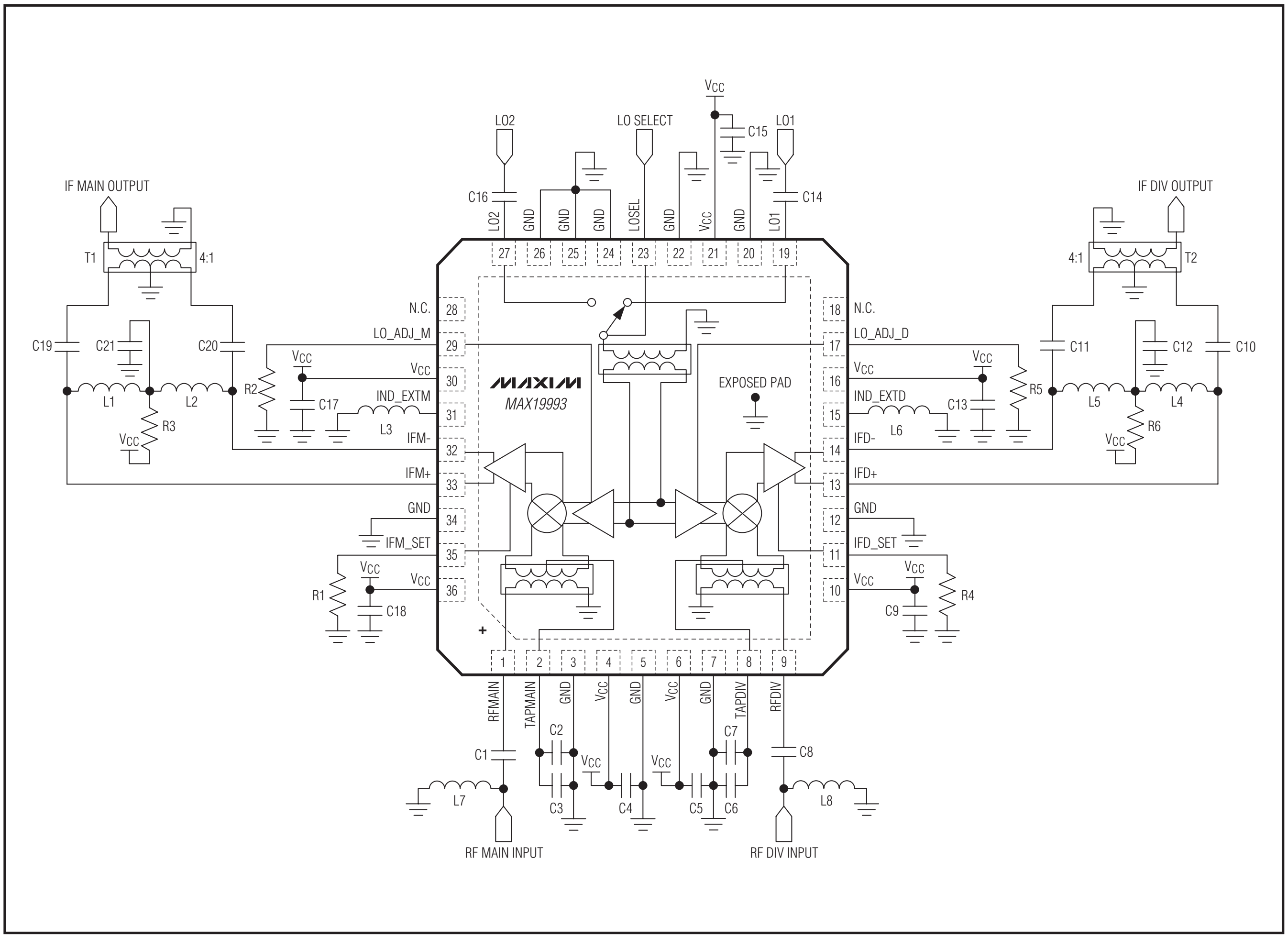


Table 1. Component Values

DESIGNATION	QTY	DESCRIPTION	COMPONENT SUPPLIER
C1, C2, C7, C8, C14, C16	6	39pF microwave capacitors (0402)	Murata Electronics North America, Inc.
C3, C6	2	0.033µF microwave capacitors (0603)	Murata Electronics North America, Inc.
C4, C5	2	0402, not used	—
C9, C13, C15, C17, C18	5	0.01µF microwave capacitors (0402)	Murata Electronics North America, Inc.

Table 1. Component Values (continued)

DESIGNATION	QTY	DESCRIPTION	COMPONENT SUPPLIER
C10, C11, C12, C19, C20, C21	6	150pF microwave capacitors (0603)	Murata Electronics North America, Inc.
L1, L2, L4, L5	4	330nH wire-wound high-Q inductors (0805)	Coilcraft, Inc.
L3, L6	2	0Ω resistors (0603). For improved RF-to-IF and LO-to-IF isolation, contact factory for details.	Digi-Key Corp.
L7, L8	2	Additional tuning elements (0402, not used)	—
R1, R4	2	681Ω ±1% resistors (0402). Used for **V_{CC} = 5.0V** applications. Larger values can be used to reduce power at the expense of some performance loss.	Digi-Key Corp.
		681Ω ±1% resistors (0402). Used for **V_{CC} = 3.3V** applications.	
R2, R5	2	1.82kΩ ±1% resistors (0402). Used for **V_{CC} = 5.0V** applications. Larger values can be used to reduce power at the expense of some performance loss.	Digi-Key Corp.
		1.43kΩ ±1% resistors (0402). Used for **V_{CC} = 3.3V** applications.	
R3, R6	2	0Ω resistors (1206)	Digi-Key Corp.
T1, T2	2	4:1 transformers (200:50) TC4-1W-7A	Mini-Circuits
U1	1	MAX19993 IC (36 TQFN-EP)	Maxim Integrated Products, Inc.

Chip Information

PROCESS: SiGe BiCMOS

Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
36 Thin QFN-EP	T3666+2	**21-0141**	**90-0049**

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/10	Initial release	—